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LIMITATION OF THE RESOLUTION
OF RADIOTELESCOPES AND RADIOINTERFEROMETERS
ON ACCOUNT OF CONDITIONS OF RADIOWAVE PROPAGATION
IN SPACE AND IN THE EARTH'S ATMOSPHERE

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IN SPACE AND IN THE EARTH'S ATMOSPHERE *

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S U M M A R Y

The influence of the conditions of radiowave propagation in the in the Earth's atmosphere and in the cosmic space on the threshold resolution of antennas and of interferometers is reviewed in this paper. It is shown that when certain conditions, imposed on the frequency band and the time constant, are observed, the antenna dimensions may be practically unlimited in the centimeter and short decimeter waves, while the length of interferometers' base is not confined, only for waves shorter than 15 cm.

* * *

In order to estimate the dimensions of very remote radiogalaxies, radiotelescopes with great threshold resolution are required to make possible the investigations of brightness distribution of small radio emission sources and the ascertaining of the "pointness" of the objects suspected to be artificial. Assuming that the increase in radiotelescope dimensions should not, in the nearest future, cause any technical difficulties, we shall estimate their threshold resolution, limited only by the conditions of radiowave propagation in nonuniform media, such as the Earth's atmosphere and the cosmic gas.

* OGRANICHENIYE RAZRESHAYUSHCHEY SILY RADIOTELESKOPOV I RADIOINTERFEROMETROV ZA SCHET USLOVIY RASPROSTRANENIYA RADIOVOLN V KOSMICHESKOY SREDE I V ATMOSFERE ZEMLI.

The nonuniformity n of the index of refraction of a medium with mobile condensations distributed at random leads to the perturbation of the wave's phase front, and by way of consequence, to scattering (see Fig. 1).

The mean square of phase deflections from the unperturbed one for a ray having crossed the inhomogeneous medium is [1]

$$\overline{\varphi^2} = \frac{4\pi^2 S r}{\lambda^2} \overline{\Delta n^2}, \quad (1)$$

and the angle of scattering in the geometric optics' approximation is

$$\sqrt{\overline{\sigma^2}} = 2\pi^{1/2} \sqrt{\frac{S}{r} \overline{\Delta n^2}}, \quad (2)$$

where $\sqrt{\overline{\Delta n^2}}$ is the root-mean square deflection of the index of refraction; r is the correlation radius (mean dimension of nonuniformities or irregularities); S is the path of the ray in the medium; λ is the wavelength.

If $\overline{\varphi^2} < 1$, a halo form around the source on account of scattering; this halo does not hinder the determination of source's dimensions, but it weakens the flux in the principal direction, so that [2]

$$P = (1 - \overline{\varphi^2}) P_0 \text{ at } \overline{\varphi^2} \ll 1.$$

At strong scattering, when $\overline{\varphi^2} \geq 1$, random refractive errors and a fictitious magnification of source's dimensions, determined by the expression (2), may be observed. Both phenomena may limit the threshold resolution of the radiotelescopes. In

order to estimate these effects, the parameters of the irregularities are essential, namely $\overline{\Delta n^2}$, r , S , whose oriented values for various media are compiled in the Table 1 [next page] (refer to [3-19]).

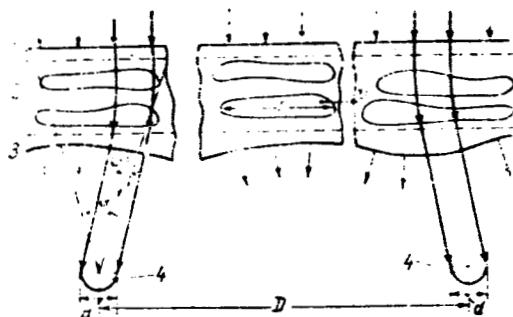


Fig. 1. - Distortion of wave's phase front. The scattering angle is smaller than the angular dimension of the irregularity.

1 - wave's plane front; 2 - nonuniform layer; 3 - distorted wave front; 4 - antennas.

TABLE 1

MEDIUM		S, cm	r, cm	$\sqrt{\Delta n^2}$	ANNOTATIONS
Troposphere [3, 4]	at zenith	$1.5 \cdot 10^6$	$6 \cdot 10^3$	$0.5 \cdot 10^{-6}$	$S = \left(S_{TP} + \frac{\Delta n_{np}^2}{\Delta n_{TP}^2} S_{HP} \right) \operatorname{cosech}$ $S_{TP} = 5 \cdot 10^4 \text{ cm. is the thickness of the troposphere at zenith.}$
	near the horizon ($h \approx 10^\circ$)	$9 \cdot 10^6$	$6 \cdot 10^3$	$0.5 \cdot 10^{-6}$	$S_{HP} = 10^4 \text{ cm is the thickness of near-Earth' layer}$ $\sqrt{\Delta n_{np}^2} = 10 \sqrt{\Delta n_{TP}^2} = 0.5 \cdot 10^{-4}.$ <p>whence $S = 1.5 \cdot 10^4 \operatorname{cosech}$ The absence of cloudiness is assumed.</p>
Ionosphere [5 - 10]	quiet	$4 \cdot 10^7$	$2 \cdot 10^4$	$4.5 \cdot 10^{-12}$ λ^2	$\sqrt{\Delta N^2} = 10^{-2} N = 10^2 \text{ cm}^{-3}$
	perturbed	$4 \cdot 10^7$	10^6	$4.5 \cdot 10^{-10}$ λ^2	$\sqrt{\Delta N^2} = N = 10^4 \text{ cm}^{-3}$
Interplanetary [11 - 16]	in the ecliptic plane*	10^{14}	10^9	$4.5 \cdot 10^{-12}$ λ^2	$\sqrt{\Delta N^2} = N = 10^4 \text{ cm}^{-3}$ **
	in the dir. of the ecl. pole	$0.5 \cdot 10^{13}$	10^9	$0.9 \cdot 10^{-12}$ λ^2	$\sqrt{\Delta N^2} = N = 20 \text{ cm}^{-3}$ **
Interstellar [17-19]	in the galactic pl.	$6 \cdot 10^{22}$	$3 \cdot 10^{18}$	$4.5 \cdot 10^{-14}$ λ^2	$\sqrt{\Delta N^2} = N = 1 \text{ cm}^{-3}$
	in the dir. of Galaxy pole	$6 \cdot 10^{20}$	$3 \cdot 10^{18}$	$4.5 \cdot 10^{-14}$ λ^2	
Metagalactic [17, 19]		10^{28}	10^{22}	$4.5 \cdot 10^{-19}$ λ^2	$\sqrt{\Delta N^2} = N = 10^{-3} \text{ cm}^{-3}$

Denotations and Remarks

S is the path of the ray in the medium; r is the correlation radius; N is the concentration of electrons; λ is the wavelength; $\sqrt{\Delta n^2}$ is the root-mean-square deflection of the index of refraction.

* At observation in the direction to the Sun;

** assuming that the dimension of irregularities varies little at drifting away from the Sun.

The widening of the angular dimensions of the point source to the value $\sqrt{\sigma^2}$ will be observed in the faraway zone of scattering regions (at a distance $R \approx S \gg r^2/\lambda$). - As follows from the data of the Table 1 above,

and from the expression (1), in all cases when $\bar{\varphi}^2 \geq 1$, this condition is not satisfied on Earth. The terrestrial observer is situated in the nearby zone of scattering irregularities, and in this case the correlations between the scattering angle $\sqrt{\sigma^2}$, the angular diameter of scattering regions $\sqrt{\alpha^2}$ and the relative dimension of the antenna of the system d/r are essential for the limitation of the threshold resolving power.

At fulfillment of the correlation

$$\sqrt{\sigma^2} > \sqrt{\alpha^2} \quad (3)$$

the rays, having passed the regions of the medium at distances exceeding the correlation radius, and correspondingly different in their direction (Fig. 2 a), will hit the system (of any dimension). The beam of rays will go separate ways, and the source will be found widened by a magnitude of the order $\sqrt{\sigma^2}$. In this case the resolution of the antenna system will be limited by the value of this widening. If

$$\sqrt{\sigma^2} \ll \sqrt{\alpha^2}, \quad (4)$$

the effect may become different for continuous antennas and for interferometers; at the same time a substantial dependence of antenna system's dimensions must be observed.

Waves, having crossed the regions of the medium at distances exceeding the correlation radius and having in connection with this uncorrelated phase shifts (Fig. 2 b), will hit either a continuous or multielement antenna system with dimensions $d > r$.

The phase fluctuations will cause the loss of the effective surface of the antenna and the widening of its radiation pattern. Requiring that the loss of antenna amplification in the principal direction do not exceed 30 percent, we shall find, according to [20], that at $\bar{\varphi}^2 \geq 1$ the dimensions of the antenna must not exceed the value

$$d = mr, \quad \text{where} \quad 0.5 \leq m \leq 2 \quad (5)$$

depending upon the value of $\bar{\varphi}^2$ and consequently the antenna's resolving power will be $0 \geq \lambda/mr$.

When the conditions (4) are satisfied, the antenna with relative dimension $d/r \leq 1$ will be hit by rays having crossed the region of the medium with dimension less than r (Fig. 1) and having received in connection

with that identical deflections. In case of fixed irregularities, the source's passing through antenna pattern will not widen its lobe. Only an uncertainty of the order $\sqrt{\delta^2}$ will appear in the source's coordinate.

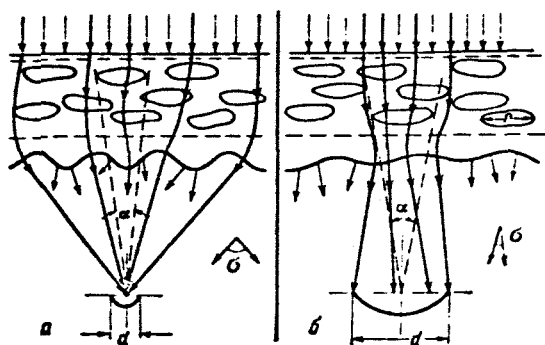


Fig. 2. - Widening of source's angular dimensions:

α - angle of scattering greater than the angular dimension of the irregularity, antenna dimension $d \ll r$. δ - antenna dimension greater than that of the irregularity $d > r$. The antenna receives radiation from all directions within the limits of the scattering angle

The motion of irregularities will induce the oscillation of the angle of radiation arrival, which may limit the antenna's resolving power. If during the time T of source's passing through antenna radiation pattern (in the regime of passage or of a slowed-down slipping) the shift of radiation's incidence angle and the corresponding widening of the curve of passage will reach the value of lobe widening $\Delta\theta \ll \theta = \lambda/d$ and it may be then neglected. (At the same time the uncertainty in source's dimensions lies within the range

$\theta < \Delta\theta_{\text{source}} < \lambda/ld$ where $l \simeq 2 - 3$, depending upon the distribution of

brightness by the source and the shape of antenna's radiation pattern [24, 25]) The shift of the angle of arrival during the time T is, by order of magnitude, equal to

$$\Delta\theta \simeq \begin{cases} \sqrt{\sigma^2} T/t & \text{at } T < t, \\ \sqrt{\sigma^2} & \text{at } T \geq t. \end{cases} \quad (6a)$$

(6b)

Here $t = r/v$ is the characteristic time of irregularity passage, v is the motion velocity of the irregularity. Let us rewrite the requirement $\Delta\theta \ll \theta$ taking into account (6a), in the form

$$\sqrt{\sigma^2} T/t \ll \lambda/d$$

and consequently

$$T \ll \frac{\lambda}{d} \frac{t}{\sqrt{\sigma^2}}$$

Taking into account the relationship between $\overline{\varphi^2}$ and $\overline{\sigma^2}$ stemming from (1) and (2), we have :

$$V_{\overline{\sigma^2}} = \lambda V_{\overline{\varphi^2}} / \pi r,$$

and hence we obtain the limitation for the registration time :

$$T \ll \pi \frac{t}{V_{\overline{\varphi^2}}} \frac{r}{d}. \quad (7)$$

Taking into account that the time constant τ of the output device must be by several factors shorter than T , we shall obtain

$$\tau \ll \frac{t}{V_{\overline{\varphi^2}}} \frac{r}{d}. \quad (8)$$

In the transitional regime $T = \lambda / d \Omega \cos \delta$, where Ω is the angular velocity of Earth's rotation and δ is the source's declination, the condition for which incident angle oscillations can be neglected, will become

$$V_{\overline{\sigma^2}} / t \ll \Omega \cos \delta = 7 \cdot 10^{-5} \cos \delta \text{ sec}^{-1} \quad (9)$$

All the preceding discussions referred to one of the frequencies of the admitted band. However, as a result of dispersion ($V_{\overline{\alpha^2}} = a \dot{\lambda}^2$ from (2) and Table 1), taking place for all media except the troposphere, the incident angles of the radiation in different wavelengths within the bands of admitted frequencies will be different. This may lead to a fictitious increase of source's dimensions by a value

$$\Delta V_{\overline{\sigma^2}} = \Delta \frac{ac^2}{v^3} = 2ac^2 \frac{\Delta v}{v^3} = 2 V_{\overline{\sigma^2}} \frac{\Delta v}{v},$$

where $\Delta v / v$ is the relative frequency band. This effect may again be neglected provided $\Delta V_{\overline{\sigma^2}} < \theta = \lambda / d$, whence stems the requirement that the width of the frequency band be

$$\Delta v < \frac{\lambda}{d} \frac{v}{2 V_{\overline{\sigma^2}}} = \frac{\pi}{2} \frac{v}{V_{\overline{\varphi^2}}} \frac{r}{d}. \quad (10)$$

Therefore, the dispersion and the oscillations of the incidence angle limiting the frequency band and the time constant to the values (10) and (8), determine the radiotelescope's threshold response

$$T_s = \frac{\pi T_m}{V \Delta \nu T} \gg T_m V \sqrt{2} \frac{V \overline{\varphi^2}}{V \nu t} \frac{d}{r},$$

where T_m is the integral noise temperature of the radiotelescope, taking into account the scattering in the antenna and the absorption at propagation. The wave's phase variation, linked with the motion of medium's irregularities, must induce the widening of signal's spectrum by

$$V \overline{\Delta \nu^2} = V \overline{\varphi^2} / 2\pi t,$$

which may result essential during analysis of the radiation received from a monochromatic source, for the estimate of processes, taking place in it and the investigation of the peculiarities of the medium in which the radiation propagates. Thus, at fulfillment of correlations (8) and (10), and also of the condition (4), continuous or multielement antennas may have a dimension close to r , but must not be substantially greater, (see (5)). However, as will be shown below, a two-antenna interferometer with antennas having a dimension $d \ll r$, can have a base D significantly exceeding r . The measurement of brightness distribution

$$T(\xi) = (1/2\pi) \int_{-\infty}^{\infty} \bar{T}(s) \exp(2\pi j S \xi) d\xi$$

of the radioemission source with the help of two-antenna interferometers is based upon the determination of the spectrum of spatial frequencies or of complex visibility function [21]

$$\bar{T}(s) = \frac{P_{\text{max}}(s) - P_{\text{min}}(s)}{P_{\text{max}}(s) + P_{\text{min}}(s)} \exp\left(2\pi j \frac{\theta_0(s)}{\theta(s)}\right),$$

where $P_{\text{max}}(s)$ and $P_{\text{min}}(s)$ are the maximum and minimum values of signal power at interferometer output with a base $D = s\lambda$; $\theta_0(s)$ is the angular scattering between two maxima of the envelope and of the zero lobe; $\theta(s)$ is the width of the lobe. The phase fluctuations make $\theta_0(s)$ a random quantity, oscillating near the true value which can be determined only as a result

of numerous measurements. For the determination of the dimensions of sources at given models of brightness distribution about the source, it is sufficient to measure the module of the visibility function [22, 23]

$$V = (P_{\text{max}} - P_{\text{min}}) / (P_{\text{max}} + P_{\text{min}}),$$

which requires either the registration of the lobe transition curve, or separate measurement of the variable and constant signal components, respectively proportional to $(P_{\text{max}} - P_{\text{min}})$ and $(P_{\text{max}} + P_{\text{min}})$. Since the interferometer is designed for the registration of radiation fluxes of quite low power, in order to obtain the required sensitivity one must ensure an accumulation during a sufficient time. To that effect it is possible to slow down the source's passage velocity through the pattern, introducing such an accompaniment by its lobe radiation pattern, so as the lobes pass during a sufficiently longer time, or apply a resonance filter to variable component frequency with a sufficiently narrow frequency band $\omega_{\text{H}} = 1/\tau$. The fluctuations of phase difference on interferometer antennas lead at the first method of registration to the disruption of the regularity of the lobe transition curve, while at the second method it results in the change of the frequency of lobes' passage by $\Delta\omega = V\sqrt{\Delta\varphi^2}/t^*$.

In order to obtain the values of the visibility function's module with admissible distortions, the delay of lobes' registration at the first registration must not be so great as to have the fluctuational incursion of phase difference $(V\sqrt{\Delta\varphi^2}/t)\tau$ become, during the period τ of lobe registration, — greater than 1 radian, while when applying the second method, the frequency band of the resonance contour at interferometer output must be

$$\Delta\omega_{\text{H}} = 1/\tau > \Delta\omega = V\sqrt{\Delta\varphi^2}/t.$$

Therefore, no matter what the method of registration, we have $\tau < t/V\sqrt{\Delta\varphi^2}$.

* This circumstance allows, so long as we do not set up the problem of measurement of visibility function's phase, to lower the requirements of heterodyne stability on interferometer antennas to the value

$$\frac{\Delta\omega}{\omega} = \begin{cases} \frac{D}{r} \frac{V\sqrt{\Delta\varphi^2}}{\omega t}, & D < r, \\ \frac{V\sqrt{\Delta\varphi^2}}{\omega t}, & D > r. \end{cases}$$

Taking into account that the phase difference of rays, hitting the interferometer antennas and divided by the distance D , is

$$V_{\Delta\varphi^2} = \begin{cases} \frac{D}{r} V_{\varphi^2} & \text{at } D < r, \\ V_{\varphi^2} & \text{at } D > r, \end{cases} \quad (11)$$

we obtain the limitation for the time constant of the output device

$$\tau < \begin{cases} \frac{r}{D} \frac{t}{V_{\varphi^2}} & \text{at } D < r, \\ \frac{t}{V_{\varphi^2}} & \text{at } D > r. \end{cases} \quad (12)$$

The total registration time $T = N\tau$, on which the interferometer sensitivity is dependent is also determined by the width of the envelope of the lobe structure and the velocity of its displacement relative to the source. When the envelope is fixed, it will be of the order of the time of source's passage through the multilobe radiation pattern of the interferometer, bounded by the envelope, that is $T = (\lambda/D)(v/\Delta v)(1/\Omega)$; hence $\Delta v T = (\lambda/D)(v/\Omega) = c/D\Omega$, (Ω being the angular velocity of Earth's rotation). In the regime of source's accompaniment by the envelope, T may be sufficiently great.

The frequency band Δv is determined by the requirement that the differential phase difference on interferometer antennas at frequency band edges, conditioned by dispersion, be

$$d V_{\Delta\varphi^2} = \frac{d V_{\Delta\varphi^2}}{dv} \Delta v = V_{\Delta\varphi^2} \frac{\Delta v}{v} < 1,$$

whence, taking into account (11), we obtain

$$\begin{aligned} \frac{\Delta v}{v} &< \frac{r}{D} \frac{1}{V_{\varphi^2}} & \text{at } D < r, \\ \frac{\Delta v}{v} &< \frac{1}{V_{\varphi^2}} & \text{at } D > r. \end{aligned} \quad (13)$$

Thus, when observing the conditions (12) and (13), the base D of the two-antenna interferometer may be significantly greater than the correlation

radius of the scattering regions \underline{r} on the condition that the dimension of interferometer antennas be $d \ll r$.

For the estimate of the threshold resolution of antenna systems we have recourse to Table 2, in which the values of $\overline{\varphi^2}(\lambda), \sqrt{\overline{\sigma^2}(\lambda)}, \sqrt{\overline{\alpha^2}}, t$, are compiled alongside with the wavelength ranges in which $\overline{\varphi^2} > 1$, $\sqrt{\overline{\sigma^2}} \ll \sqrt{\overline{\alpha^2}}$. It may be seen from Table 2 that the greatest phase disturbances are undergone by the wave at crossing the cosmic medium. The troposphere may provide a strong scattering ($\overline{\varphi^2} > 1$) only in microwaves*, while the disturbed ionosphere - in wavelengths > 40 cm. Therefore, the dimension of continuous antennas in these ranges is limited, according to (5) by a magnitude comparable with the dimension of irregularities of the corresponding media. The condition

$$\sqrt{\overline{\sigma^2}} > \sqrt{\overline{\alpha^2}}$$

at which widening of the source by a quantity of the order $\sqrt{\overline{\sigma^2}}$, takes place, and the limitation of antenna systems' resolution by this quantity linked with it, is fulfilled in the interplanetary medium in wavelengths $\lambda >$ at observation in the ecliptic plane (toward the side of the Sun) and in wavelengths > 10 m in the direction of the ecliptic pole, and also in the interstellar medium (in the Galaxy plane) in decameter wavelengths. However, the angle of scattering, conditioned by the influence of the interstellar gas, is small by comparison with that provided by the interstellar medium, and it may be neglected. The partial widening $0 < \Delta\theta_{\text{scr}} < \sqrt{\overline{\sigma^2}}$ of the source on account of scattering in the interplanetary medium may be observed in the 15 - 20 cm band at observation in the ecliptic plane and, correspondingly, in the 3 - 10 m wavelengths in the direction of the ecliptic pole. For all remaining media (where $\overline{\varphi^2} \geq 1$) and for the interplanetary gas at waves < 15 cm (in the ecliptic plane) and < 3 m (in the direction of the ecliptic pole) $\sqrt{\overline{\sigma^2}} \ll \sqrt{\overline{\alpha^2}}$, and the widening of the point

* The influence of clouds and hydrometeors is not considered here, for the unique investigations of extreme small radioemission sources may be carried out at favorable weather conditions. The near-Earth layer is only taken into account in the inclined ray and the phase fluctuations on the horizontal trace of that layer are not considered, for it is estimated possible to construct a radiotelescope in which high-frequency channels, passing in the turbulent near-Earth layer, are absent, or an automatic correction is introduced, accounting phase fluctuations at propagating on the horizontal trace.

source will not be substantial if the conditions (8), (10) and $d \ll r$ are satisfied for continuous antennas and (12), (13) for the interferometers.

MEDIUM		$\overline{\varphi^2}, \text{rad}^2$	V_{σ^2}, rad	V_{α^2}, rad	t, sec	Wave band where	
						$\overline{\varphi^2} < 1$	$V_{\sigma^2} \ll V_{\alpha^2}$
Troposphere	at zenith	$\frac{0.16 \text{ cm}^2}{\lambda^2}$	$2.1 \cdot 10^{-5}$	10^{-2}	3 - 5	$\lambda < 0.4 \text{ cm}$	entire band
	near the horizon	$\frac{0.95 \text{ cm}^2}{\lambda^2}$	$5.1 \cdot 10^{-5}$	10^{-3}	3 - 5	$\lambda < 1 \text{ cm}$	entire band
Ionosphere	disturbed *	$5.6 \cdot 10^{-4} \lambda^2$	$7.5 \cdot 10^{-9} \lambda^2$	$2.5 \cdot 10^{-2}$	50	$\lambda > 42 \text{ cm}$	$\lambda < 5.7 \cdot 10^2$
Interplanetary	in the ecliptic plane	$1.4 \cdot 10^2 \lambda^2$	$4 \cdot 10^{-9} \lambda^2$	10^{-5}	50	entire band	$\lambda < 16 \text{ cm}$
	in the direction of the ecliptic pole	$0.28 \lambda^2$	$1.7 \cdot 10^{-10} \lambda^2$	$2 \cdot 10^{-4}$	50	$\lambda > 2 \text{ cm}$	$\lambda < 3.5 \cdot 10^2 \text{ cm}$
Interstellar	in the galactic plane	$2.5 \cdot 10^{16} \lambda^2$	$1.7 \cdot 10^{-11} \lambda^2$	$5 \cdot 10^{-5}$	10^{12}	entire band	$\lambda < 5.5 \cdot 10^2 \text{ cm}$
	in the direction of Galaxy pole	$2.5 \cdot 10^{14} \lambda^2$	$1.7 \cdot 10^{-12} \lambda^2$	$5 \cdot 10^{-3}$	10^{12}	entire band	entire band
Metagalactic		$1.4 \cdot 10^{15} \lambda^2$	$1.2 \cdot 10^{-15} \lambda^2$	10^{-6}	10^{14}	entire band	entire band

$\overline{\varphi^2}$ — mean square of phase incursion; V_{σ^2} is the scattering angle; V_{α^2} is the angular dimension of the irregularity; t is the time of its displacement.

* For an undisturbed ionosphere $\overline{\varphi^2} = 1.5 \cdot 10^{-9} \lambda^2$ and the scattering is immaterial within the radioastronomy band.

On the basis of the above-presented calculations we constructed a graph (see Fig. 3), showing what threshold resolution (in seconds of arc) can be attained with the help of continuous antenna and interferometers in various wavelengths.

It follows from the graph of Fig. 3 that :

1. - In the microwave band, where the restriction is laid on by the troposphere, the threshold resolution of antennas has an order of a few seconds of arc and, depending upon the angle of the spot, is included between the values determined by the curves $a\delta$ and $a'\delta'$, plotted for the observation respectively at zenith and near horizon (at $h = 10^\circ$).

2. - The centimeter and short decimeter wave band, for which only scattering in the interplanetary gas is material, is optimum for continuous (compact) antennas. Here the resolution may attain values of $10^{-2} - 10^{-3}$ sec of arc at observation in the ecliptic plane (segment $\delta\epsilon$ of the curve) and still greater values in other directions.

3. - Over the longwave portion of the decimeter band and in meter waves the threshold resolution of antennas is worse than 10 sec of arc. The portion $\delta\epsilon$ is determined by scattering in the disturbed ionosphere. At observation in the ecliptic plane the resolving power is limited by the portion of the curve $e'\kappa$ (and not $e'e$ as at observation near the ecliptic pole), which characterizes the widening of source's dimensions on account of scattering in the interplanetary medium.

4. - The resolution of a two-antenna interferometer is not limited in wavelengths $\lambda < 15$ cm at observation in the ecliptic plane and $\lambda < 3$ m in the direction of the ecliptic pole.

5. - The resolution of the interferometer in waves $\lambda > 50$ cm at observation in the ecliptic plane and in waves $\lambda > 10$ m in the direction of the ecliptic pole is restricted by the value of the corresponding widening of the point source $\sqrt{\sigma^2}$ conditioned by the interplanetary gas ($\delta\kappa, \epsilon\kappa$).

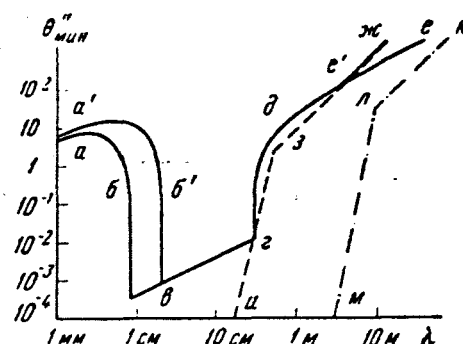


Fig. 3. - Threshold resolution of antenna systems:

solid curves — for compact (or multielement) antennas; dashes — for interferometers at observation in the ecliptic plane; dash-dotted — for interferometers at observation in the direction of ecliptic pole.

6. - In the intermediate region $15 \text{ cm} < \lambda < 50 \text{ cm}$ (in the ecliptic plane) and $3 \text{ m} < \lambda < 10 \text{ m}$ (in the ecliptic pole), the resolving power is limited by the quantity $\Delta\theta$ lying within the limits $0 < \Delta\theta < 1/\sqrt{3}$ (segments $u\theta$ and $\kappa\theta$).

The estimates brought out in Fig. 3, bear a rough, approximate character, since experimental data on the irregularity of the cosmic medium and of the disturbed ionosphere are still scarce. The parameters, characterizing the irregularities of the troposphere, have climatic peculiarities and a seasonal course. As a result, the resolutions obtained here for the radiotelescopes of the microwave band may vary. The construction of radiotelescopes of extremely high resolution could serve, alongside with the main problem of investigation, for making more precise the parameters of the troposphere, ionosphere and interplanetary medium also.

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*** THE END ***

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